

WHAT IS CLAIMED IS:

1. A circuit board testing apparatus for testing a plurality of wirings formed on a circuit board, each wiring having a first terminal and second terminal, the apparatus comprising:

an electromagnetic wave irradiator which irradiates an electromagnetic wave onto a first terminal of a selected one of the wirings to discharge electrons from the irradiated terminal by photoelectric effect;

an electrode disposed at such a position as to trap the discharged electrons;

a voltage supplier which produces a difference of electric potential between the electrode portion and the other terminal of the selected wiring so that the electrode portion has an electrical potential higher than the other terminal of the selected wiring;

a current detector which detects a current caused by electrons trapped by the electrode and flows through the selected wiring via the electrode; and

a judger which determines existence of open-circuit and/or short-circuit based on the current detected by the current detector.

2. The circuit board testing apparatus according to claim 1, wherein the electromagnetic wave irradiator includes a deflector which changes the direction of the electromagnetic wave in such a manner as to selectively and successively irradiate the first terminals of the plurality of wirings with the electromagnetic wave.

3. The circuit board testing apparatus according to claim 1, wherein the voltage supplier includes a power source, and a connector which connects the power source, the electrode, the second terminal of the selected wiring, and the current detector with one another to constitute a closed circuit thereby.

4. The circuit board testing apparatus according to claim 3, wherein the connector includes a plurality of probes which are to be brought into contact with the respective second terminals of the plurality of wirings to establish electrical connections therewith, and a switch which selectively connects the plurality of probes to the power source.

5. The circuit board testing apparatus according to claim 1, further comprising a housing which encloses the first

terminals of the plurality of wirings to constitute an airtight closed space, and a depressurizer which depressurizes the closed space.

5           6. The circuit board testing apparatus according to claim 5, wherein the upper portion of the housing is transparent, the electric magnetic wave irradiator is located above the housing to irradiate the first terminals through the upper portion of the housing, and the electrode is formed on the housing.

7. The circuit board testing apparatus according to claim 6, wherein the electrode includes a transparent electrode formed on an upper portion of the housing.

15           8. The circuit board testing apparatus according to claim 6, wherein the electrode portion includes a meshed electrode formed on the upper portion of the housing, and the electromagnetic wave irradiator irradiates the first terminal through the upper portion of the housing not covered by the  
20 meshed electrode.

9. The circuit board testing apparatus according to claim 6, wherein the side wall of the housing is made of electrically

conductive material to function as the electrode.

10. The circuit board testing apparatus according to claim  
1, wherein the voltage supplier includes a power source having  
5 two poles, and a connector which connects the selected wiring to  
one pole of the power source, and at least a part of the  
unselected wirings to the other pole of the power source so that  
the wirings connected with the other pole of the power source  
serves as the electrode.

11. The circuit board testing apparatus according to claim  
1, wherein the voltage supplier includes a power source having at  
least two poles, and a switch arrangement which connects the  
selected wiring to one pole of the power source, and all the  
15 unselected wirings to the other pole of the power source so that  
the wirings connected with the other pole of the power source  
serves as the electrode.

12. The circuit board testing apparatus according to claim  
20 1, wherein the voltage supplier includes a power source, and a  
switch which connects the second terminal of the selected wiring  
to the power source.

13. The circuit board testing apparatus according to claim 1, wherein the voltage supplier includes a power source, and a switch which connects the power source to the second terminal of a wiring adjacent to the selected wiring of which first terminal is irradiated by the electromagnetic wave.

14. A circuit board testing apparatus for testing continuity and/or short-circuit of wirings formed on a circuit board, each wiring having first and second terminals, the apparatus comprising:

an electromagnetic wave irradiator which irradiates the first terminals of the wirings with an electromagnetic wave to allow electrons to be discharged from the first terminals by photoelectric effect;

an electrode arranged to trap discharged electrons;

a voltage supplier for applying a voltage between the electrode and the second terminals of the wiring in a manner that voltage at the electrode becomes higher than voltage at the second terminals of the wirings;

a current detector which detects an electric current which is caused by electrons trapped by the electrode and flows through the wirings via the electrode; and

a judger which determines existence of open-circuit and/or

short-circuit of the wirings based on the current detected by the current detector.

15. The circuit board testing apparatus according to claim 14, wherein the electromagnetic wave irradiator is arranged to alternatively irradiate the terminals one at a time, and the voltage supplier is to be alternatively connected with the second terminals of the wirings one at a time.

16. A circuit board testing apparatus for testing a plurality of wirings of a circuit board, each wiring including a terminals formed on a surface of the circuit board and an electric conductor formed on the surface of or inside the circuit board and electrically connected to the terminal, the apparatus comprising:

an electromagnetic wave irradiator which selectively and successively irradiates terminals of the wirings with an electromagnetic wave one by one to discharge electrons from the irradiated terminal by photoelectric effect;

a first electrode disposed to trap the discharged electrons;

a second electrode capacitively coupled to conductors of the plurality of wirings;

a power source provided between the first electrode and the

second electrode to cause a difference of an electric potential in such a manner that the first electrode has a potential higher than that of the second electrode;

a current detector which detects a current caused by the discharged electrons which flows through a circuit including the first electrode, the power source, and the capacitive coupling; and

a judger which judges whether the electric conductor of the selected wiring is continuous, based on a current value detected by the current detector when the first terminal is irradiated by the electromagnetic wave and another current value detected by the current detector when another terminal is irradiated by the electromagnetic wave.

17. A circuit board testing apparatus for testing a plurality of wirings formed on a circuit board, at least one of the wirings including a first and second terminals formed on a surface of the circuit board and a conductive portion formed on the surface of the circuit board or inside the circuit board and electrically connected to the terminals, the apparatus comprising:

an electromagnetic wave irradiator which selectively and successively irradiates terminals of the wirings with an

electromagnetic wave one by one to discharge electrons from the irradiated terminal by photoelectric effect;

a first electrode portion disposed at such a position as to trap the discharged electrons;

5 a second electrode portion capacitively coupled to the plurality of wirings;

a power source provided between the first electrode portion and the second electrode portion to cause a difference of electric potential in such a manner that the first electrode portion has a potential higher than that of the second electrode portion;

a current detector which detects a current caused by discharged electrons which flows through a circuit including the first electrode, the power source, and the capacitive coupling;  
15 and

a judger which judges whether a conductive portion of the selected wiring between the first terminal and second terminal is continuous based on a current value detected by the current detector when the electromagnetic wave is irradiated onto the first terminal of the target wiring and another current value detected by the current detector when the electromagnetic wave is irradiated onto the second terminal of the target wiring.  
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18. A circuit board testing apparatus for testing a circuit board formed with a plurality of wirings, each wiring including a terminal formed on a surface of the circuit board and a conductive portion formed on the surface of the circuit board or inside the circuit board and electrically connected to the terminal, the apparatus comprising:

an electromagnetic wave irradiator which selectively and successively irradiates an electromagnetic wave onto terminals of the wirings one by one to discharge electrons from the terminal by photoelectric effect;

a first electrode disposed at such a position as to trap the discharged electrons;

a second electrode capacitively coupled to at least a part of the selected wiring;

a power source provided between the first electrode and the second electrode to apply a voltage in such a manner that the first electrode has a potential higher than that of the second electrode;

a current detector which detects a current caused by discharged electrons which flows through a circuit including the first electrode, the power source, and the capacitive coupling; and

a judger which determines existence of open-circuit and/or

short-circuit based on the current detected by the current detector.

19. The circuit board testing apparatus according to claim 18, further comprising a housing which encloses terminals of the plurality of wirings to constitute an airtight closed space, and a depressurizer which depressurizes the closed space.

20. The circuit board testing apparatus according to claim 18, wherein the circuit board to be tested includes a ground layer, and the power source is connected to the ground layer so that the ground layer is capacitively coupled to at least a part of the selected wiring to thereby serve as the second electrode portion.

21. The circuit board testing apparatus according to claim 18, further comprising a connector which connects the power source to a terminal connected with one of the plurality of wirings of the circuit board to be tested so that the terminal serve as the first electrode portion for trapping discharged electrons.

22. The circuit board testing apparatus according to claim

18, wherein the circuit board to be tested includes a ground layer, and the apparatus further comprising a connector which connects the power source to a terminal connected with one of the plurality of wirings of the circuit board to be tested so that the terminal serve as the first electrode portion for trapping discharged electrons, and connects the power source to the ground layer so that the ground layer is capacitively coupled to at least a part of the selected wiring to thereby serve as the second electrode portion.

23. A circuit board testing apparatus for testing a plurality of wirings formed on a circuit board, each wiring having a first and second terminals and the first terminals of the wirings being exposed on one surface of the circuit board, comprising:

an electromagnetic wave irradiator which collectively irradiates the first terminals of the wirings with electromagnetic wave to discharge electrons from the first terminals by photoelectric effect;

an electrode arranged to trap the discharged electrons;

a selector for selecting one of the wirings;

a voltage supplier which produces a difference of electric potential between the electrode and the second terminal of a

selected wiring so that the electrode has an electrical potential higher than that of the second terminal of the selected wiring;

a current detector which detects a current caused by electrons trapped by the electrode portion to flow through the selected wiring via the electrode; and

a judger which judges continuity and/or short-circuit of the selected wiring based on the detected current.

24. The circuit board testing apparatus according to claim 23, wherein the voltage supplier includes a power source having a first pole connected to the electrode and the second pole connected to the second terminal of the target wiring, and the selector includes a switch arrangement for electrically connects the second terminals of the wirings other than the selected wiring, to the first pole of the power source.

25. The circuit board testing apparatus according to claim 23, wherein the voltage supplier includes a power source having a first pole connected to the electrode and a second pole connected to the second terminal of the target wiring, and the selector has a switch arrangement for electrically connecting the second terminal of the selected wiring to the second pole of the power source by way of the current detector, and the respective

second terminals of the wirings other than the selected wiring to the second pole of the power source bypassing the current detector.

5           26. The circuit board testing apparatus according to claim  
25, wherein the selector includes a switch to select one state  
where the second terminal of the selected wiring is electrically  
connected to the second pole of the power source by way of the  
current detector and the second terminals of the wirings other  
10 than the selected wiring are electrically connected to the second  
pole of the power source bypassing the current detector, and  
another state where the second terminal of the selected wiring is  
electrically connected to the second pole of the power source by  
way of the current detector and the second terminals of the  
15 wiring other than the selected wiring are electrically connected  
to the first pole of the power source.

27. The circuit board testing apparatus according to claim  
23, further comprising a housing which encloses the second  
20 terminals of the plurality of wirings to form an airtight closed  
space, and a depressurizer which depressurizes the closed space.

28. The circuit board testing apparatus according to claim

27, wherein the upper wall of the housing is transparent, the electromagnetic wave irradiator is located above the housing to irradiate the first terminals through the transparent wall, and the electrode is formed on the housing in the manner allowing the  
5 passage of the electromagnetic wave through the transparent wall.

29. A circuit board testing apparatus for testing a plurality of wirings formed on a circuit board, each wiring having a first and second terminals and the first terminals of the wirings being exposed on one surface of the circuit board, comprising:

an electromagnetic wave irradiator which collectively irradiates the first terminals of the wirings with electromagnetic wave to discharge electrons from the first  
15 terminals by photoelectric effect;

a power source having a first pole and a second pole, the potential at the first pole being higher than at the second pole;

a switch arrangement for normally connecting the second terminals of all the wirings with the first pole of the power  
20 source and connecting the second terminal of one of the wirings to the second pole of the power source while the electromagnetic wave irradiator irradiating the first terminals, and

a current detector which detects a current caused by

electrons trapped by the first terminals of the wirings other than the selected wiring connected with the second pole of the power source, and flows through the selected wiring; and

5 a judger which judges continuity and/or short-circuit of the selected wiring based on the detected current.

30. A method for testing continuity and/or short-circuit of wirings formed on a circuit board, each wiring having a first and second terminals, the method comprising the steps of:

10 irradiating the first terminal of a wiring with electromagnetic wave to discharge electrons from the terminal into a space by photoelectric effect;

trapping the discharged electrons by an electrode having a potential higher than that at the second terminal of the wiring  
15 to allow a current caused by the trapped electrons to flow from the second terminal through the wiring; and

judging continuity and/or short-circuit of the wiring based on the current flowing through the wiring.

20 31. The method according to claim 30, further comprising the steps of:

enclosing the space into which electrons are discharged; and depressurizing the closed space, those steps being carried

out before the irradiation step.

32. The method according to claim 30, wherein the  
electromagnetic wave is selectively and successively irradiated  
5 onto the first terminals of the wirings one by one, and an  
electrical potential difference is produced between the electrode  
and the second terminal of the selected wiring in such a manner  
that the electrode has a potential higher than that of the  
selected wiring.

33. The method according to claim 30, wherein the  
electromagnetic wave is selectively and successively irradiated  
onto the one terminals of the wirings one by one, and a  
difference of electric potential is produced between the  
15 electrode and a second terminal of the wiring adjacent to the  
selected wiring in such a manner that the electrode has a  
potential higher than that of the second terminal of the wiring  
adjacent to the selected wiring.

20 34. The method according to claim 30, wherein the  
electromagnetic wave is selectively and successively irradiated  
onto the first terminals of the wirings, and a difference of  
electric potential is produced between the electrode and the



second terminal of the selected wiring or between the electrode and the second terminal of the wiring adjacent to the selected wiring in such a manner that the electrode has a potential higher than that of second terminal of the selected wiring or the wiring  
5 t adjacent to the selected wiring.

35. A method for testing a plurality of wirings formed on a circuit board, each wiring including a terminal formed on a surface of the circuit board and a conductive portion formed on the surface of the circuit board or inside the circuit board and electrically connected to the terminal, the method comprising the steps:

irradiating an electromagnetic wave onto the terminal of a wiring to discharge electrons from the terminal into a space by  
15 photoelectric effect;

trapping the discharged electrons by a first electrode having an electrical potential higher than that of the wiring;

allowing a current caused by the trapped electrons to flow through the wiring via a capacitive coupling formed by the wiring  
20 and second electrode connected to the first electrode ; and

judging continuity and/or short-circuit of the wiring based on the current flowing through the wiring.

36. The method according to claim 35, wherein the space into which the electrons are discharged is air-tightly enclosed, and the method further comprising the step of depressurizing the closed space.

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37. The method according to claim 35, wherein the circuit board includes a ground layer capacitively coupled with the conductor of the target wiring, and the method further comprising the step of connecting a power source to the ground layer to allow the current caused by the trapped electrons to flow through the conductive portion via the capacitive coupling to the ground layer.

38. A method for testing a plurality of wirings formed on a circuit board, each wiring including a first and second terminals formed on a surface of the circuit board and an electric conductor formed on the surface of the circuit board or inside the circuit board and electrically connected to the terminals, the method comprising the steps:

irradiating an electromagnetic wave onto a first terminal of a target wiring to discharge electrons from the first terminal into a space by photoelectric effect;

trapping the discharged electrons by a first electrode

having an electric potential higher than that of the target wiring;

allowing a current caused by the trapped electrons and flowing into the conductor via a capacitive coupling of the conductor and a second electrode connected to the first electrode;

detecting a first current flowing through the conductor while the first terminal is being irradiated;

irradiating an electromagnetic wave onto a second terminal of the target wiring to discharge electrons from the second terminal into the space by the photoelectric effect;

trapping the discharged electrons by the first electrode having an electrical potential higher than that of the target wiring;

allowing a current caused by the trapped electrons to flow through the conductor via capacitive coupling of the conductor and a second electrode;

detecting a second current flowing through the conductor while the second terminal is being irradiated; and

judging based on the first and second currents the continuity between the first and second terminals.

39. The method according to claim 38, wherein the first

current and the second current are integrated to judge, based on change of their respective integration for a time period, the continuity between the first and second terminals.

5           40. A method for testing a circuit board formed with a plurality of wirings, each wiring including a terminal formed on a surface of the circuit board and an electric conductor formed on the surface of the circuit board or inside the circuit board and electrically connected to the terminal, the conductor of all the wirings being capacitively coupled with a second electrode, the method comprising the steps:

          irradiating the terminal of the first wiring with electromagnetic wave to discharge electrons from the terminal into a space by photoelectric effect;

15           trapping the discharged electrons by a first electrode having an electric potential higher than that of the target wiring;

          allowing a current caused by the trapped electrons to flow into the conductor of the first wiring via a capacitive coupling of the conductors and the second electrode;

20           detecting a first current flowing through the conductor of the first wiring;

          irradiating the terminal of a second wiring with

electromagnetic wave to discharge electrons from the terminal of the second wiring into the space by the photoelectric effect;

trapping the discharged electrons by the first electrode having an electrical potential higher than that of the second wiring;

allowing a current caused by the trapped electrons to flow through the conductor of the second wiring via capacitive coupling of the conductors and the second electrode;

detecting a second current flowing through the conductor of the second wiring; and

judging short-circuit between the first and second wirings based on the first and second current.

41. A method for testing a continuity and/or short-circuit of a plurality of wirings formed on a circuit board, each wiring having a first and second terminals, and the first terminals of the wirings being exposed on one surface of the circuit board, the method comprising the steps of:

collectively irradiating the first terminals of the wirings with electromagnetic wave to discharge electrons from the first terminals by photoelectric effect;

selecting a wiring from the wirings;

trapping the discharged electron by an electrode, while

applying a voltage between the electrode and the selected wiring such that the voltage at the electrode is higher than that of the voltage at the selected wiring;

5 detecting a current caused by electrons trapped by the electrode and flowing through the selected wiring via the electrode; and

judging continuity and/or short-circuit of the selected wiring based on the detected current.

42. The method according to claim 41, further comprising the steps of enclosing the first terminals in an airtight closed space and depressurizing the space.

15 43. The method according to claim 41, further comprising the step of applying a voltage between the second terminal of the selected wiring and the second terminal of at least one of the wirings other than the selected wiring to detect a short-circuit between the selected wiring and the other wiring.

20 44. The method according to claim 41, further comprising the step of applying a voltage between the second terminal of the target wiring and the second terminal of at least one of the wirings other than the selected wiring to trap, by the first

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